TEAM G

ROBOGRAPHERS

FACIAL EXPRESSION RECOGNITION USING SWARMS

PRELIMINARY DESIGN REVIEW

SPONSORED BY: DR. KATIA SYCARA

TEAM : GAURI GANDHI SIDA WANG TIFFANY MAY JIMIT GANDHI ROHIT DASHRATHI

DATE: NOVEMBER 3, 2015

PROJECT DESCRIPTION

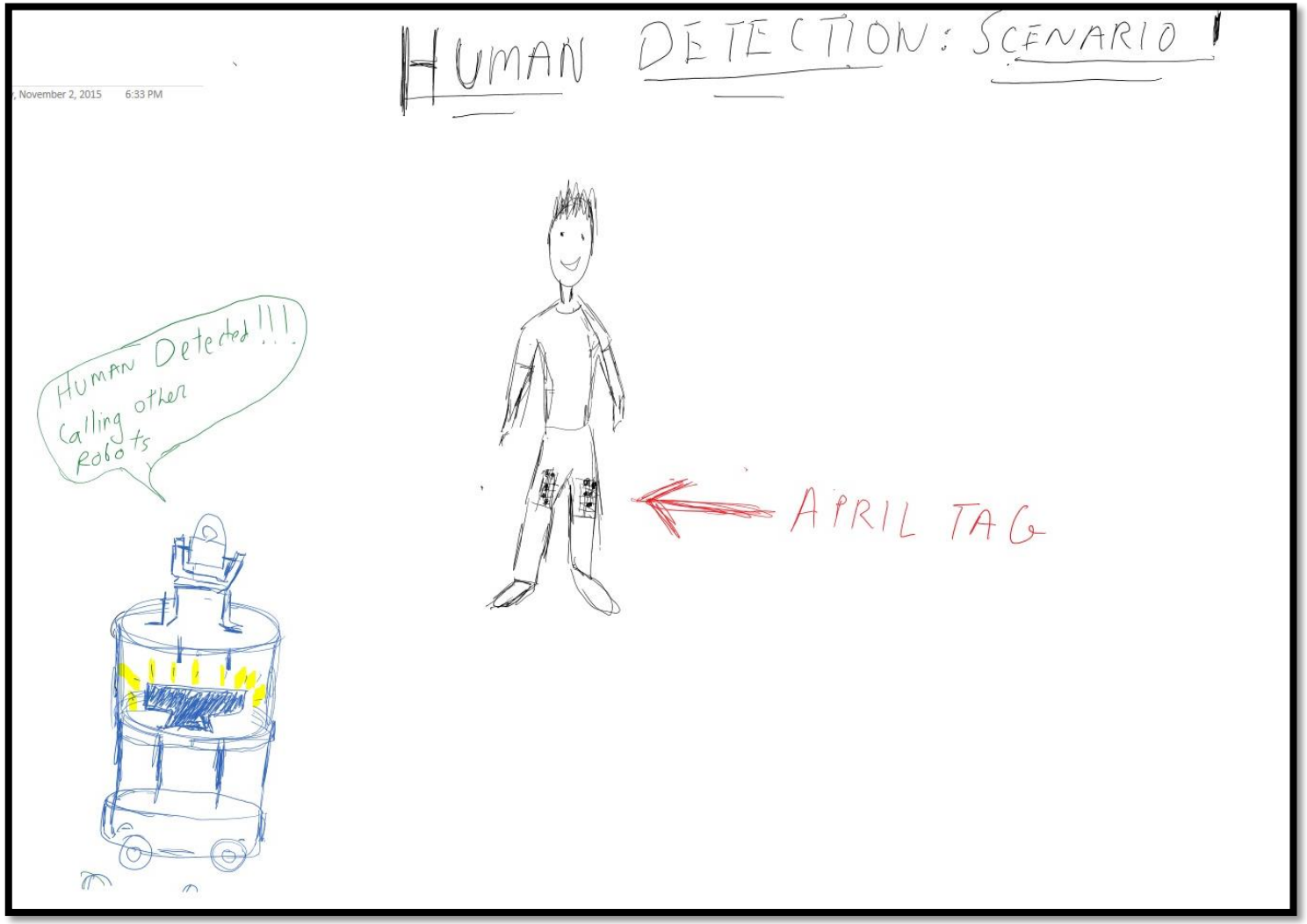
- preliminary effort aimed at developing autonomous photography assistants
- In addition to clicking photos, they recognize and capture human expressions accurately.
- Project principle: facial expression recognition and accurate head pose tracking using a swarm of robots.
- Attempt to improve the robustness and efficiency of collaborative strategies over individual planning strategies.

USER REQUIREMENTS

- Facial expression detection done by swarm mobile robots.
- Develop pan tilt mechanism capable of tracking and following human head pose.
- System will be capable of localizing each robots given a map.
- System will be capable of detecting human before reading facial expression.

USE CASE SCENARIO 1: DETECTING HUMAN

- Initially, one robot will be in the center of the room and it will rotate in place until it detects a human.
- Once it detects the human, it will call other robots to its location.
- These robots now move as a flock towards the human it detected.



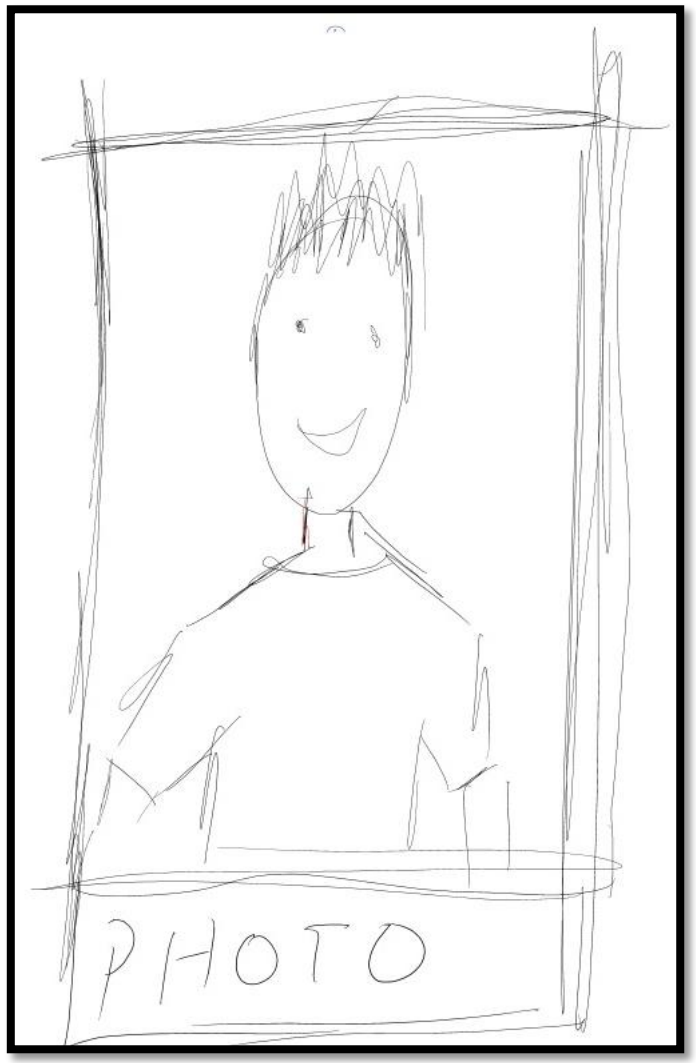
USE CASE SCENARIO 2: DETERMINING FACIAL EXPRESSIONS

- As the swarm reach about 5-6 feet from human, they will try to detect the head pose of the human.
- If head pose is successfully detected, they will spread out and cover the human from angles -30 degrees and +30 degrees from the pose.
- They will detect the expression of the human and together click the picture if he smiles.
- If he is not smiling, an audible message “Say Cheese” will be produced by one of the robots. This process will be repeated three times after which the robots will again search another human in the environment.

USE CASE SCENARIO 3: ALTERNATE SCENARIO

- If the head pose is not detected, the robots will flock around the human until they detect the head pose.
- The next steps of facial expression detection are same as those in previous use case scenario.

OUTPUT OF THE SYSTEM



MANDATORY FUNCTIONAL REQUIREMENTS

Robots in in the system shall:

~~M.F. 1: Detect Human Figures~~

M.F. 2: Detect and Follow Head Pose (Modification: Single Robot will do it, Not all!)

M.F.3: Detect Faces At 0.5s

~~M.F.4: Detect Facial Features~~

M.F.5: Detect Smile Individually & Collaboratively (Modification: Single Robot will do it, Not all!)

M.F.6: Recognise Smiling Expression At 0.4s

M.F. 7: Communicate With Each Other (Modification: for flocking)

M.F.8: Drive Autonomously Between Multiple Locations at 15-20cm/S

M.F.9: Detect Obstacles at 10 Cm Minimum Height

M.F.10: Click Photos In <1.5 S Response Time after Expression Detection

M.F.11: Click Photos When Individual Smile Assessment >50%

M.F.12: Take Pictures within 6 Ft Range

M.F.13: Click At Least 70 % Smiling Photos (Measure of Overall Performance Requirement)

M.F.14: Localize Themselves

M.F.15: Navigate Collaboratively

DESIRABLE FUNCTIONAL REQUIREMENTS

Robots in in the system shall:

D.F.1: Drive autonomously faster between multiple locations At **40 cm/s**

D.F.2: Detect Obstacles on the surface

D.F.3: Take Pictures within **20 Ft** Range

D.F.4: Click Smiling Photos only (100% Overall Performance measure)

D.F.5: Identify human figures and facial features by same camera

D.F.6: Display photos

D.F.7: Be able to print photos

D.F.8: ~~Should detect multiple faces~~

MANDATORY NON-FUNCTIONAL REQUIREMENTS

Robots in in the system shall:
M.N.1: Be Supported With Good Lighting Conditions (Fully Illuminated Human Face All the Time)
M.N.2: Have Wireless Communication mode
M.N.3: Have adjustable elevation
M.N.5: Be easy to operate
M.N.6: Should maintain physical stability (Robots should not topple)
M.N.7: Weigh not more than 11 kg
M.N.8: Should have minimum 3 robots in SWARM
M.N.9: Have minimum 2 Hrs. of battery time
M.N. 10: Not find same person again and again! (Shifted from desirables\ non functional requirements)

DESIRABLE NON-FUNCTIONAL REQUIREMENTS

Robots in the system should:

D.N.1: Have flash light for good lighting to capture photos

D.N.2: Communicate through Wi-Fi

D.N.3: Have a Graphical User Interface

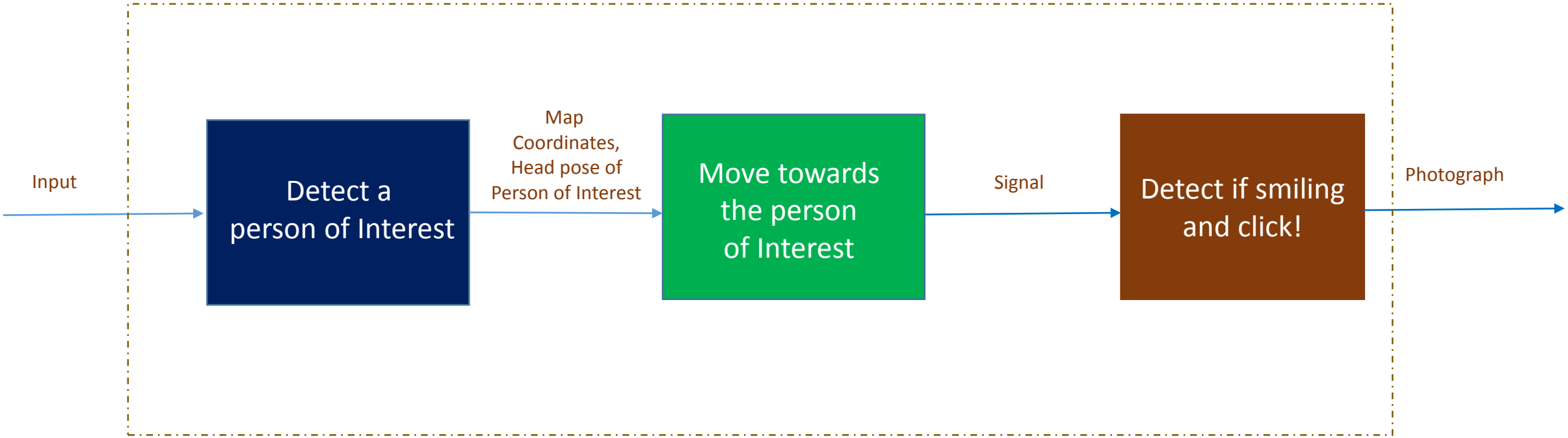
~~D.N.4: Not find same person again and again~~

D.N.5: Have small setup time

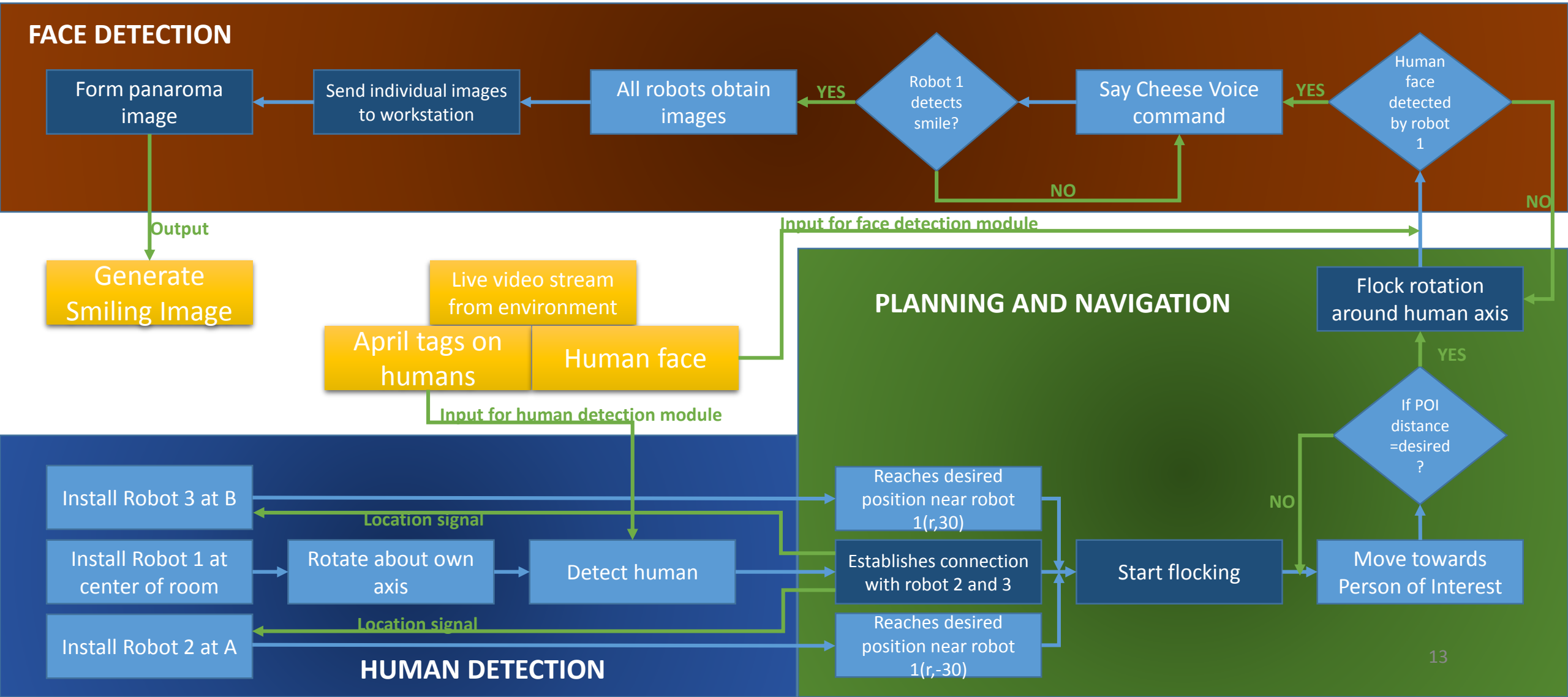
D.N.6: Have automatic adjustable elevation

D.N.7: Incorporate 6 robots in swarm

FUNCTIONAL ARCHITECTURE (REVISED)



FUNCTIONAL ARCHITECTURE (REVISED)



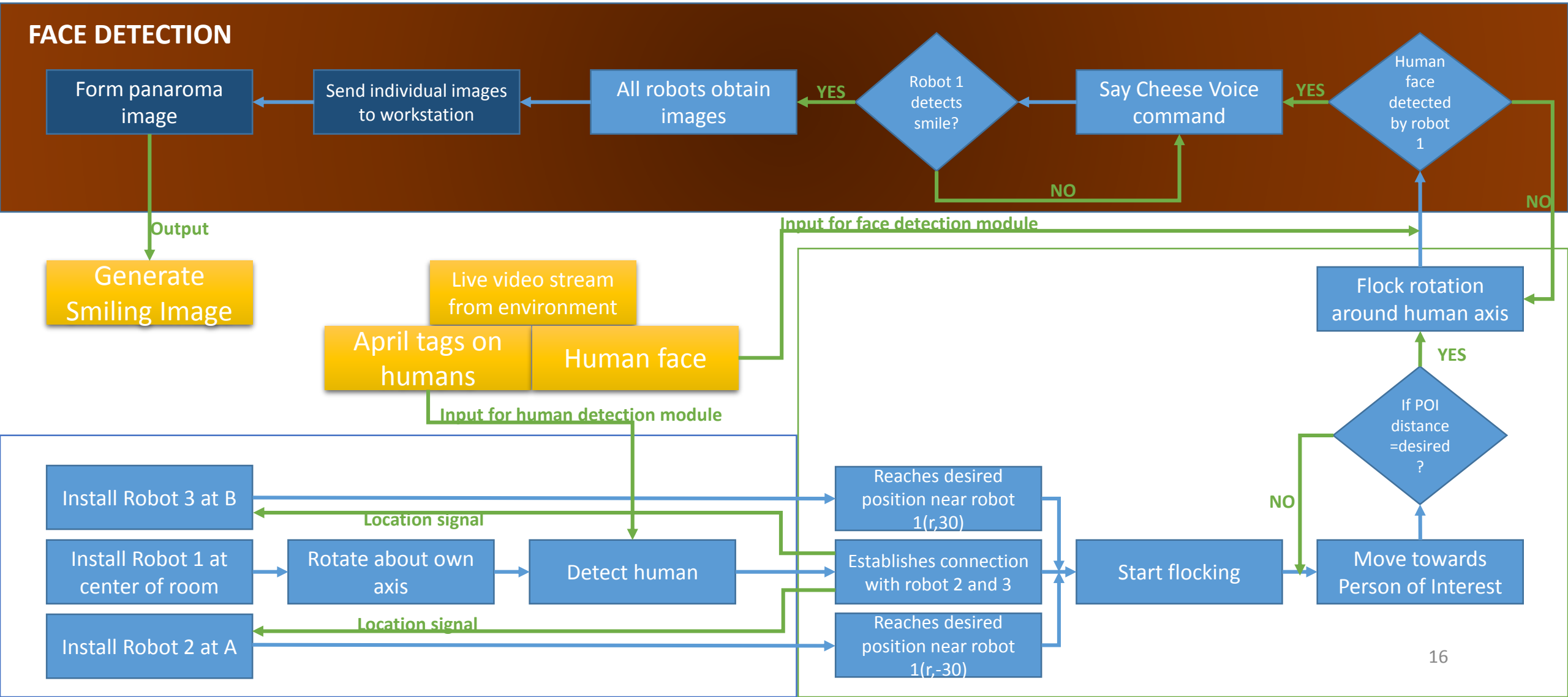
FUNCTIONAL ARCHITECTURE (REVISED)

Form panaroma image
Send individual images to workstation
All robots obtain images
YES
Robot 1 detects smile?
Say Cheese Voice command
YES
Human face detected by robot 1
NO
NO
Output
Input for face detection module
Generate Smiling Image
Live video stream from environment
April tags on humans
Human face
Input for human detection module
Flock rotation around human axis
YES
If POI distance =desired ?
NO
Install Robot 3 at B
Location signal
Install Robot 1 at center of room
Rotate about own axis
Detect human
Location signal
Install Robot 2 at A
HUMAN DETECTION
Reaches desired position near robot 1(r,30)
Establishes connection with robot 2 and 3
Reaches desired position near robot 1(r,-30)
Start flocking
Move towards Person of Interest

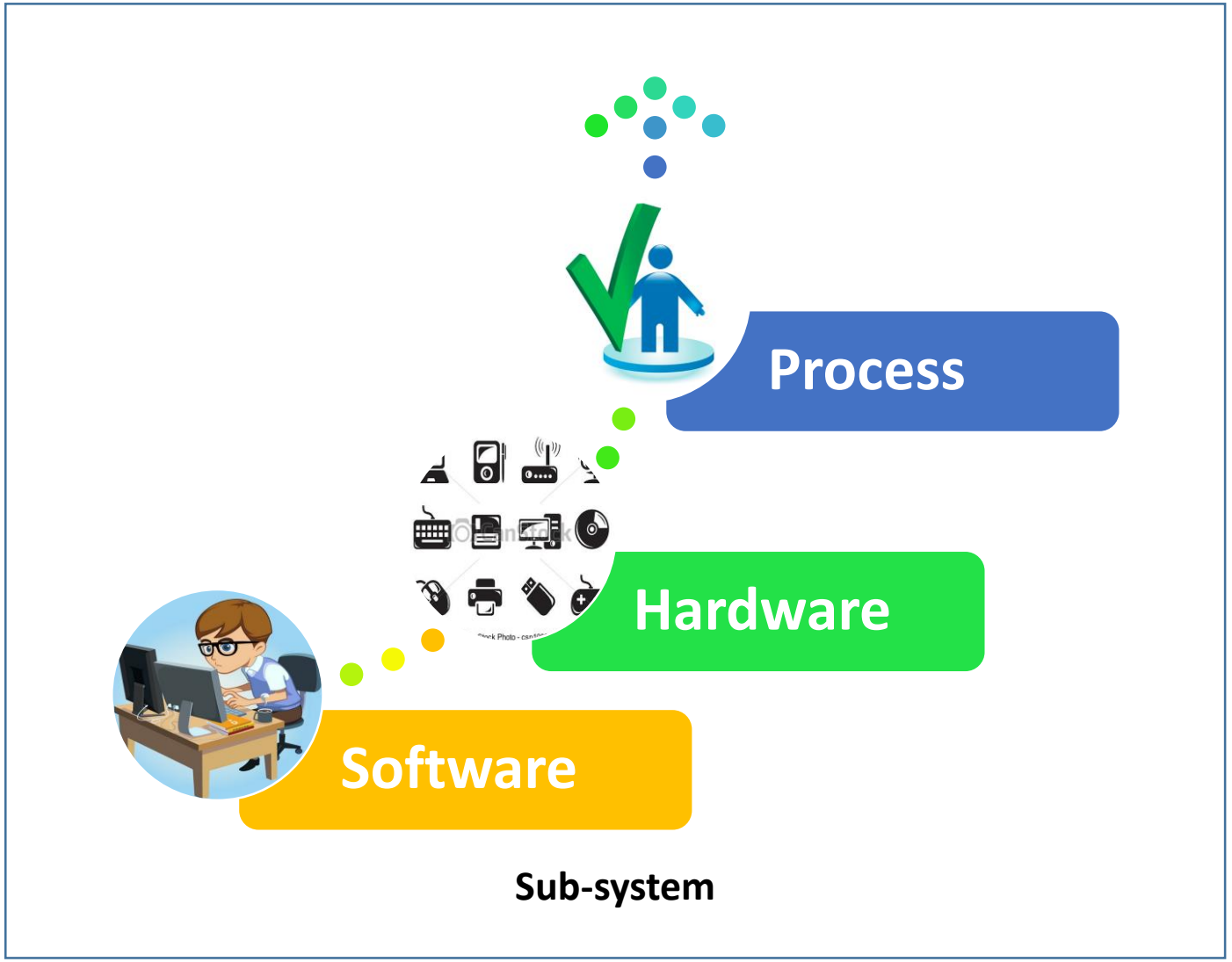
FUNCTIONAL ARCHITECTURE (REVISED)

Form panaroma image
Send individual images to workstation
All robots obtain images
YES
Robot 1 detects smile?
Say Cheese Voice command
YES
Human face detected by robot 1
NO
NO
Output
Input for face detection module
Generate Smiling Image
Live video stream from environment
April tags on humans
Human face
Input for human detection module
PLANNING AND NAVIGATION
Flock rotation around human axis
YES
If POI distance =desired ?
NO
Install Robot 3 at B
Location signal
Install Robot 1 at center of room
Rotate about own axis
Detect human
Location signal
Install Robot 2 at A
Reaches desired position near robot 1(r,30)
Establishes connection with robot 2 and 3
Reaches desired position near robot 1(r,-30)
Start flocking
Move towards Person of Interest

FUNCTIONAL ARCHITECTURE (REVISED)



CYBER-PHYSICAL ARCHITECTURE (REVISED)



CYBER-PHYSICAL ARCHITECTURE (REVISED)

Environment Setup	Robot 1 rotates about its axis	Detects human	Turtlebot 1 connects to 2 and 3	Turtlebot 2 and 3 localize around Turtlebot 1	Swarm of turtlebots flocks together	Flock moves to POI
April tags across room	Turtlebot 1 motors	April Tag on human	WiFi	April Tag on Turtlebot 1	WiFi	Kalman filtering
Turtlebots' setup		MS Kinect on Turtlebot 1		MS Kinect on Turtlebot 2 and 3		IMU+Wheel+April Tag Odometry
World map generation in ROS	Self rotation code in ROS	Operator localization code in ROS	ROS Code for Swarm Communicarion	Relative Localization code in ROS	Flock formation code in ROS	Operator follower ROS code
Installation	Human Detection		Swarm Communication and Collaboration	Planning and Navigation	Swarm Communication and Collaboration	Planning and Navigation

CYBER-PHYSICAL ARCHITECTURE (REVISED)

Face + Head Pose detection by Turtlebot 1	Flock rotation about human axis if undetected	All turtlebots obtain image	Send images to workstation	Form Panaroma Image
PTZ Camera Unit	WiFi	PTZ Camera Unit	Workstation	Workstation
Arduino			Wifi	
Intraface Arduino Code	Flock rotation code in ROS	ROS Code for getting image	Network Configuration code on ROS	Image reconstruction code in ROS
Face Detection	Swarm Communication and Collaboration	Face Detection	Swarm Communication and Collaboration	

Click Smiling Photo!!!

SUB-SYSTEM LEVEL DESCRIPTIONS

DETECTION SUB-SYSTEM: HUMAN DETECTION

Put April Tags on the calves of human

Single Robot 1 placed at centre; rotates about its own axis

TB 1 detects Apriltag using MS KInect

ROS

Perceived information about state from April tag sent to World Model Builder in ROS

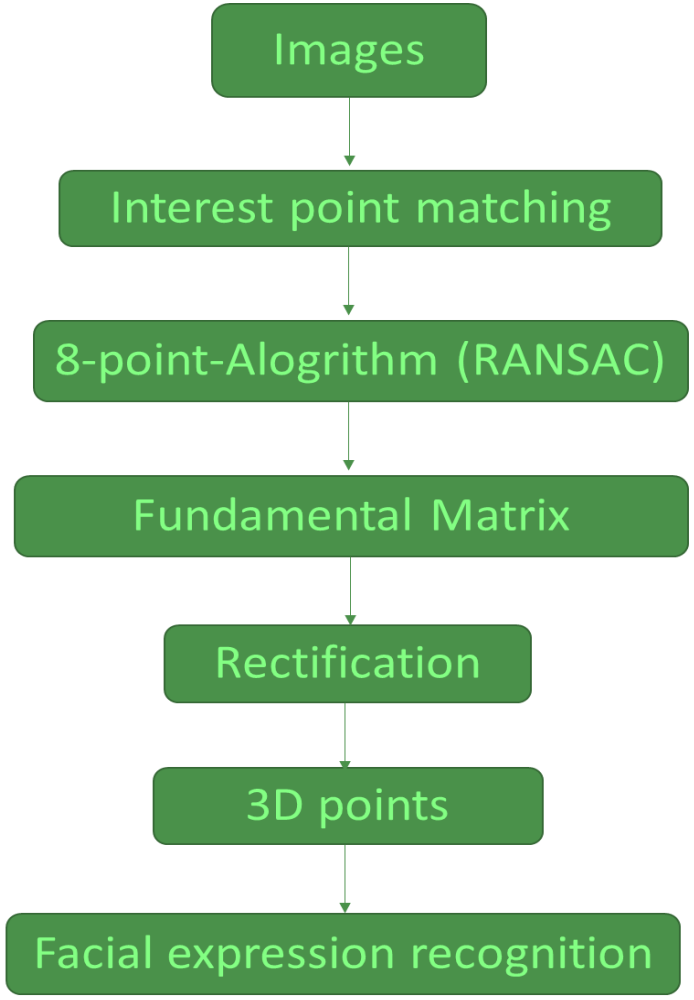
Apriltag input matched with positions in pre generated world map using ROS

Detected Human is localized in the world map

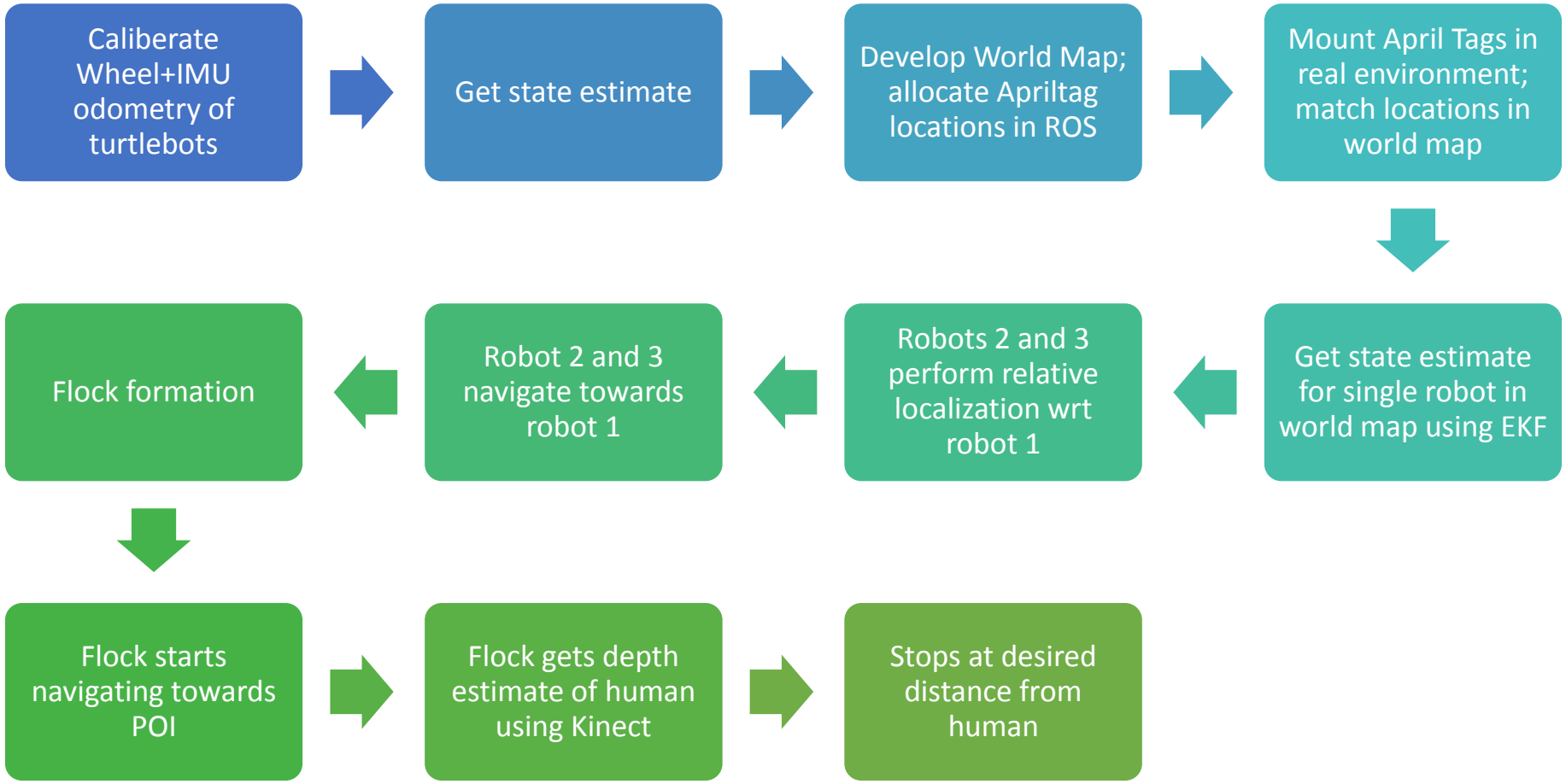
Location Signal sent over Wifi to other Turtlebots

DETECTION SUB-SYSTEM: FACE AND EXPRESSION DETECTION

IntraFace

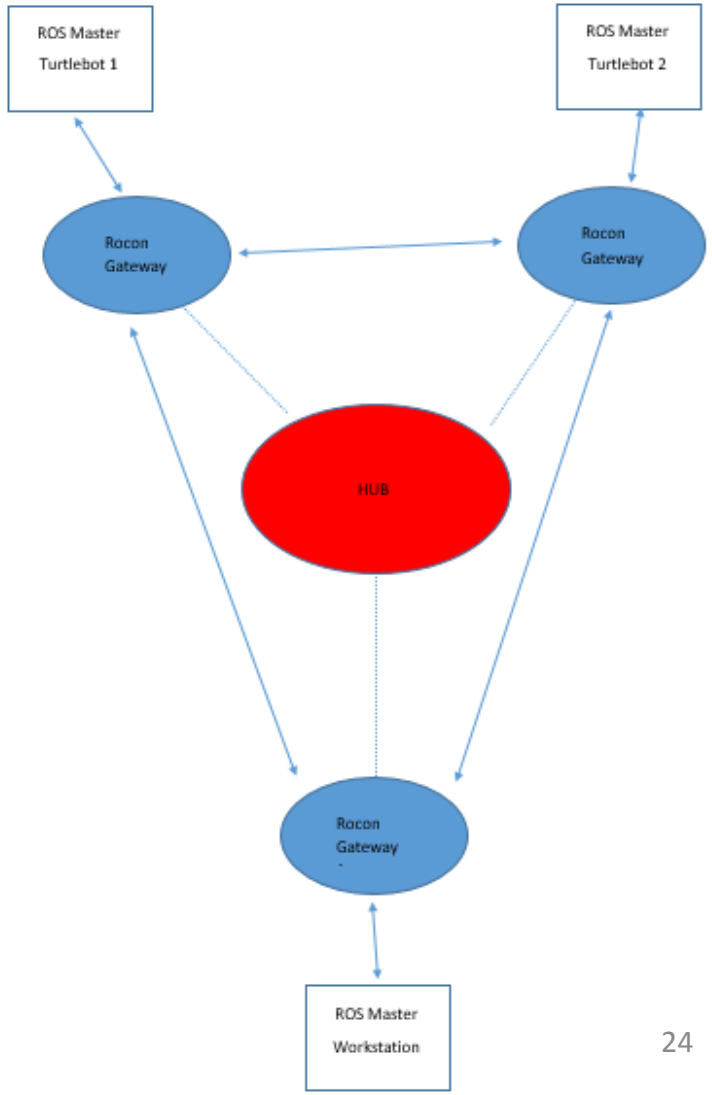


PLANNING AND NAVIGATION SUB-SYSTEM



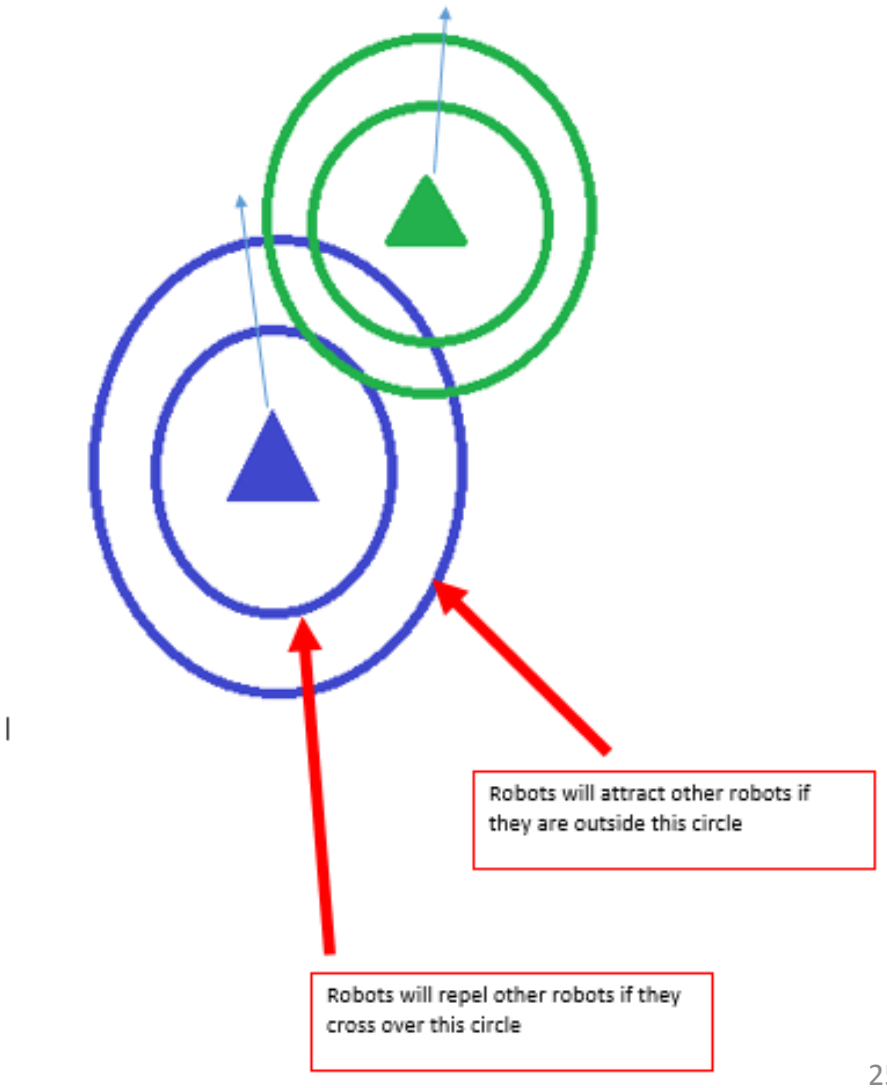
SWARM COMMUNICATION AND COLLABORATION SUB-SYSTEM

- **Rocon** framework: The name is derived from Robotics in Concert. it is a centralized multimaster system built around the ros communication layer.
- This framework has a centralized server called ***hub*** which keeps track of the active nodes called ***gateways***. It is through this gateways that different subsystems ('Turtlebots' in our case) communicate.
- The hub also keeps track of information the active gateways provide as well as the information that they require.



SWARM COMMUNICATION AND COLLABORATION SUB-SYSTEM

- **Flocking** Behaviour in Swarm Robots
- Works on three simple principles
- Attraction: Robots should be close to each other
- Repulsion: Robots should not collide with each other
- Allignment: Move together as *one single* system



SWARM COMMUNICATION AND COLLABORATION SUB-SYSTEM

Multiple View Expression Recognition

- The robots place themselves such that given a particular pose (body) of the person, at least one robot will be able to detect facial landmarks.
- The robot which can see most of the facial features will be given more weight than the robots which see partial features while calculating the overall expression.
- This will be determined by the head pose of the person which is also detected by Intraface.
- Intraface also tells you the number of features that it detects.
- Overall Expression = It will be a normalized sum of Expression value given by individual Turtlebot weighted by the number of features Intraface detects on persons face. (Exact formula will be determined according to schedule)

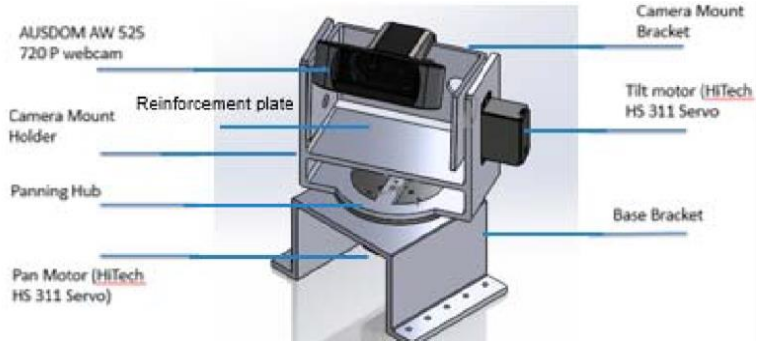
CURRENT SYSTEM STATUS

SYSTEM STATUS

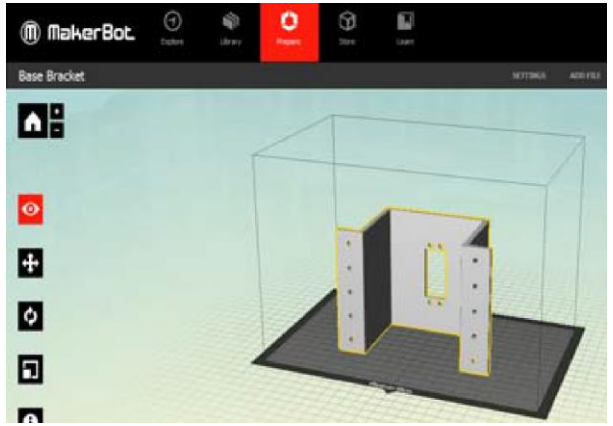
Sub-system	Status
Mechanical Assembly	3d printed working PTZ unit ready; assembled on turtlebot; tested successfully in PR2
Face Detection	Demo of Intraface software done
Human Detection	Yet to be done
Planning and Navigation	IMU and Wheel Calibration for single turtlebot done
Swarm Communication and Collaboration	Literature review in progress
Miscelleneous	Power Distribution Board Schematic done

MECHANICAL WORK STATUS

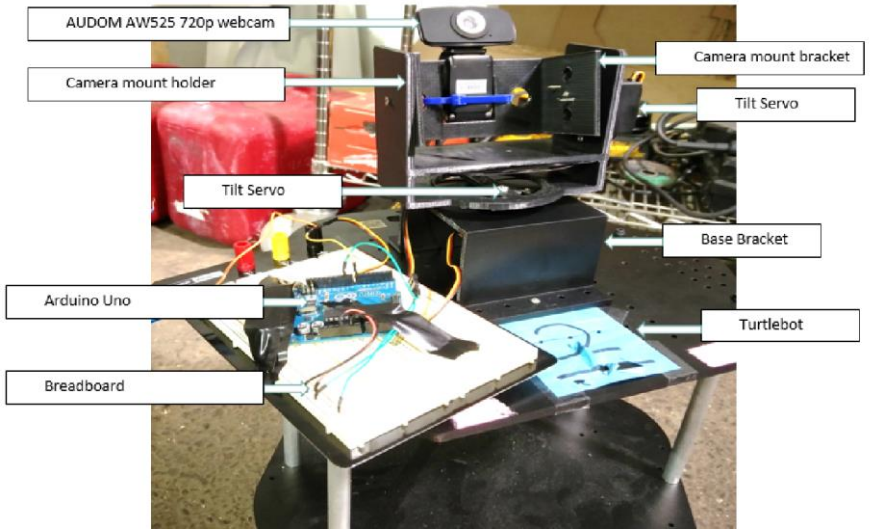
1. PTZ unit design and modelling



2. Prototype fabrication using Additive Manufacturing



3. Successful Operation in Progress Review #2



WORK BREAKDOWN STRUCTURE-FALL

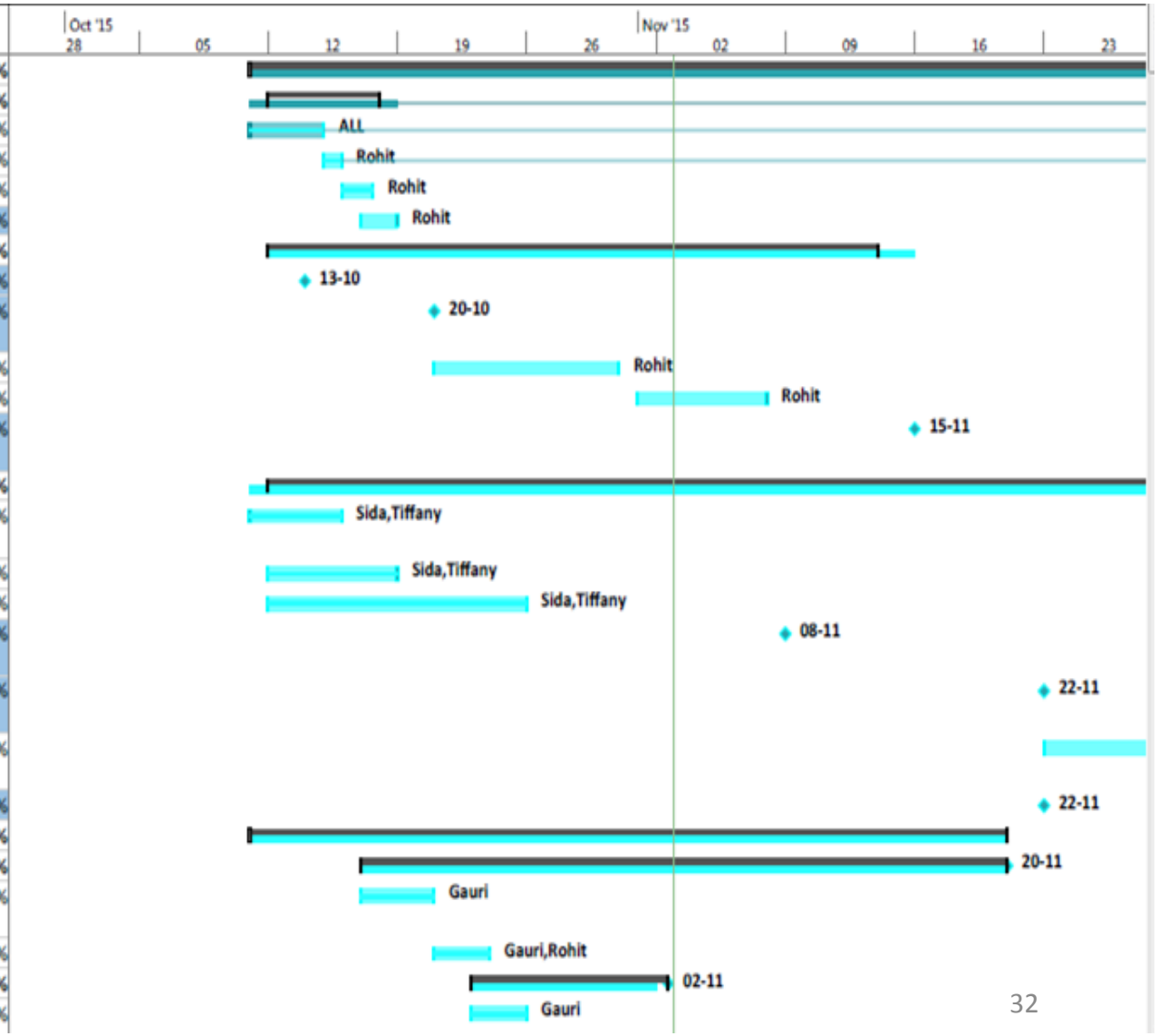
- **Robographer**
  - **1. Material Procurement**
    - **1.1 Literature Review**
      - 1.1.1 Mechanical
      - 1.1.2 Detection
      - 1.1.3 Planning-Navigation
      - 1.1.4 Collaboration
    - **1.2 Design/Analysis**
      - 1.2.1 Trades
      - 1.2.2 Parts List
      - 1.2.3 Budget
    - **1.3. Development**
      - 1.3.1 Purchase Request
  - **2. Mechanical Work**
    - **2.1 Literature Review**
      - 2.1.1 PTZ unit
      - 2.1.2 Turtlebot
    - **2.2 Design/Analysis**
      - 2.2.1 PTZ unit design
      - 2.2.2 Elevation mechanism design
      - 2.2.3 Single robot system CAD
      - 2.2.4 Weight Analysis
    - **2.3 Development**
      - 2.3.1 PTZ unit fabrication
      - 2.3.2 Elevation Mechanism fabrication
      - 2.3.3 Single robot assembly
  - **3. Detection module**
    - **3.1 Literature Review**
      - 3.1.1 Intraface, OpenCV, C++
      - 3.1.2 Turtlebot
    - **3.2 Design/Analysis**
      - 3.2.1 Human detection
        - 3.2.1.1 TB-1 Self rotation algorithm
        - 3.2.1.2 Operator detection algorithm
      - 3.2.2 Smiling face detection
        - 3.2.2.2 Pan tilt movement algorithm
        - 3.2.2.3 Say cheese! Voice command
        - 3.2.2.4 Expression recognition algorithm
        - 3.2.2.5 Photo capture algorithm
    - **3.3 Development**
      - 3.3.1 Human detection
      - 3.3.2 Expression detection
  - **4. Planning-Navigation module**
    - **4.1 Literature Review**
      - 4.1.1 Roborn Repository
      - 4.1.2 ROS familiarization
      - 4.1.3 ROBORN planning module study
    - **4.2 Design/Analysis**
      - 4.2.1 POI localization algorithm
      - 4.2.2 Navigate to POI localization algorithm
    - **4.3 Development**
      - 4.3.1 POI localization implementation
      - 4.3.2 Navigation to POI
  - **5. Collaboration module**
    - **5.1 Literature Review**
      - 5.1.1 Roborn flocking control
      - 5.1.2 Roborn exploration
      - 5.1.3 ROCON
      - 5.1.4 Multiple camera reconstruction
  - **6. Integration**
    - **6.1 Development**
      - 6.1.1 Single robot system assly
      - 6.1.2 Hardware + Detection integration
      - 6.1.3 Hardware + Detection integration
      - 6.1.3 Hardware + Detection + Planning-nav

WORK BREAKDOWN STRUCTURE-SPRING

- Robographer
  - 1. Material Procurement
    - **1.1 Design/Analysis**
      - 1.1.1 Trades
      - 1.1.2 Parts List
      - 1.1.3 Budget
    - **1.2 Development**
      - 1.2.1 Purchase Request
  - 2. Mechanical Work
    - **2.1 Design/Analysis**
      - 2.1.1 PTZ design betterment
    - **2.2 Development**
      - 2.2.1 Multiple PTZ unit fabrication
  - 3. Detection module
    - **3.1 Design/Analysis**
      - 3.1.1 Human detection
        - 3.1.1.1 Human detection with intraface feasibility
        - 3.1.1.2 Multi camera human detection feasibility
        - 3.1.1.3 Visual odometry feasibility
        - 3.1.1.4 Global camera feasibility
      - 3.1.2 Face expression detection
        - 3.1.2.4 Expression recognition algorithm
    - **3.2 Development**
      - 3.2.1 Face expression detection
        - 3.2.1.1 Multiple camera pan tilt movement
  - 4. Planning-Navigation module
    - **4.1 Design/Analysis**
      - **4**.1.1 Better localization sensing (diferent sensor than Kinect)
  - 5. Collaboration module
    - **5.1 Design/Analysis**
      - **5.1.1 Detection**
        - 5.1.1.1 Collective photo capture algorithm
      - **5.1.2 Planning-Navigation**
        - 5.1.2.1 Relative TB localization algorithm
        - 5.1.2.2 Flocking control algorithm
    - **5.2 Development**
      - **5.2.1 Detection**
        - 5.2.1.1 Collective photo capture
        - 5.2.1.2 Panaromic image fusion
      - **5.2.2 Planning-Navigation**
        - 5.2.2.1 Relative TB localization implementation
        - 5.2.2.2 Flocking control implementation
  - 6. Integration
    - **6.1 Development**
      - 6.1.1 Multiple robot system assly
      - 6.1.2 Hardware + Collaboration integration

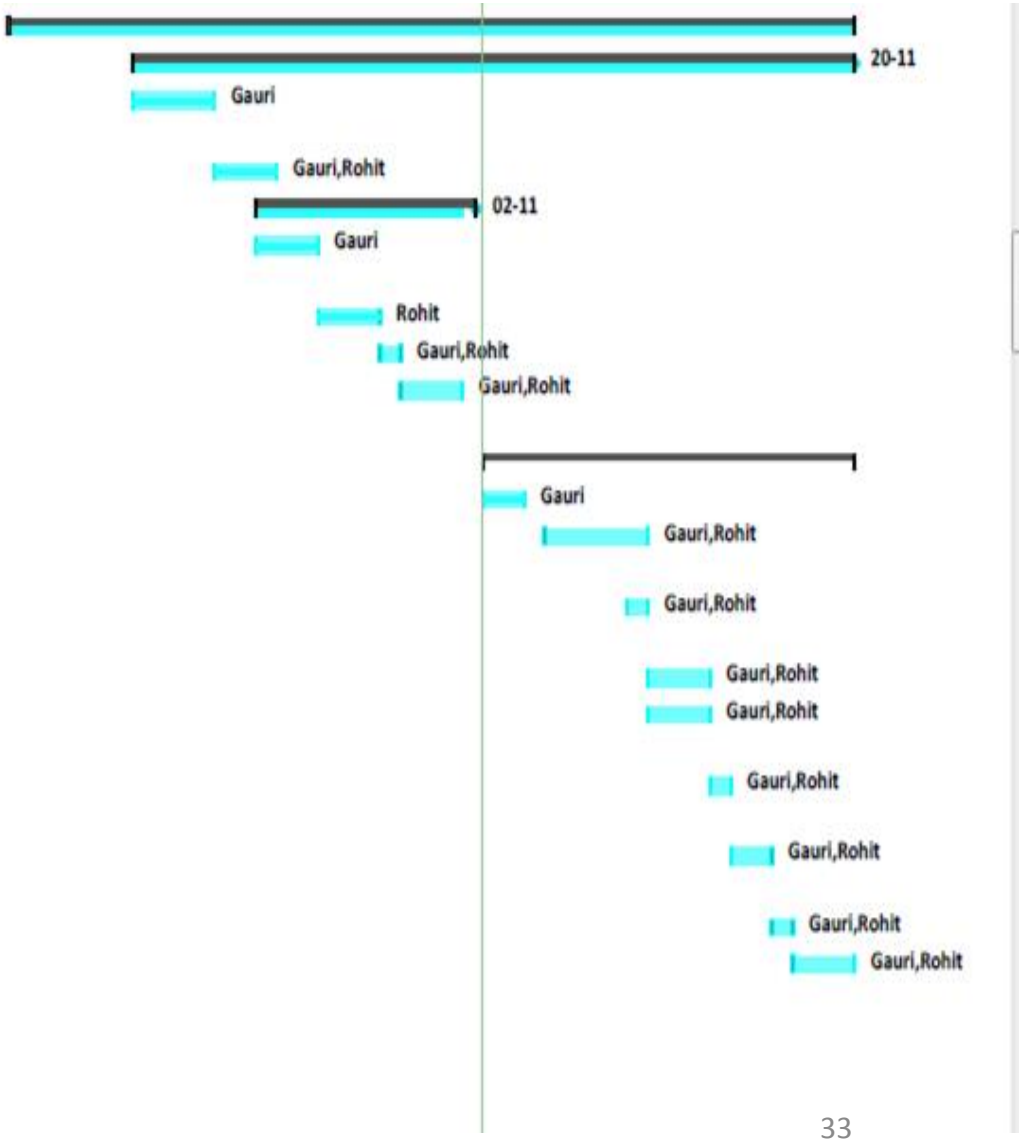
PROJECT SCHEDULE-FALL

Task Name	Duration	Start	Finish	Resource Names	% Complete
Engineering Development: Robographers	**182.56 day**	**Sun 11-10-15**	**Fri 06-05-16**		**22%**
1. Material Procurement	**6 days**	**Mon 12-10-15**	**Sun 18-10-15**	**Rohit**	**75%**
Validate Major system trades	4 days	Sun 11-10-15	Wed 14-10-1	ALL	100%
Collect From Everyone	1 day	Thu 15-10-15	Thu 15-10-15	Rohit	100%
Validate Parts list & budget	3 days	Fri 16-10-15	Sat 17-10-15	Rohit	100%
Purchase request	2.63 days	Sat 17-10-15	Sun 18-10-15	Rohit	0%
2. Mechanical Design/Development	**30.63 days**	**Mon 12-10-15**	**Sat 14-11-15**	**Rohit**	**29%**
PTZ unit and elevation rod design	3 days	Mon 12-10-15	Tue 13-10-15	Rohit	100%
3D CAD model design of single robot with equipped system	7 days	Tue 13-10-15	Tue 20-10-15	Rohit	100%
Fabrication of elevation rod	9.69 days	Wed 21-10-15	Sat 31-10-15	Rohit	0%
Elevation rod + PTZ unit assembly	7 days	Sun 01-11-15	Sun 08-11-15	Rohit	0%
(Elevation rod + PTZ unit) + Turtlebot assembly	7.5 days	Mon 09-11-15	Sun 15-11-15	Rohit	0%
3. Detection Module Design/Development	**51.75 days**	**Mon 12-10-15**	**Wed 09-12-1**	**Sida Wang,Tiffany**	**49%**
Familiarize with Intraface, openCV, C++ in Ubuntu 12.04	5 days	Sun 11-10-15	Thu 15-10-15	Sida,Tiffany	100%
Interfacing camera & zoom lense*	7.63 days	Mon 12-10-15	Sun 18-10-15	Sida,Tiffany	100%
Interfacing Camera unit & IntraFace*	13.75 days	Mon 12-10-15	Sun 25-10-15	Sida,Tiffany	100%
Facial expression recognition with Intraface using single camera	14 days	Mon 26-10-15	Sun 08-11-15	Sida,Tiffany	100%
Click single photo for best smile estimation	14.75 days	Mon 09-11-15	Sun 22-11-15	Sida,Tiffany	0%
Implement multiple photo capture avoidance	13.25 days	Mon 23-11-15	Mon 07-12-15	Sida,Tiffany	0%
Human Detection with Camera	14.75 days	Mon 09-11-15	Sun 22-11-15	Sida,Tiffany	0%
4. Planning & navigation module (Fall)	**36.19 days**	**Sun 11-10-15**	**Fri 20-11-15**	**Gauri,Rohit**	**36%**
Localization sub-module development	**30.63 days**	**Sat 17-10-15**	**Fri 20-11-15**	**Gauri,Rohit**	**39%**
Procurement of repositories, codes from Team ROBORN	3.13 days	Sat 17-10-15	Tue 20-10-15	Gauri	100%
ROS assignment tutorial	3 days	Wed 21-10-15	Fri 23-10-15	Gauri,Rohit	100%
Development of Inbuilt localization	**9.13 days**	**Fri 23-10-15**	**Mon 02-11-1**	**Gauri,Rohit**	**59%**
Turtlebot wheel calibration using ROS	3.63 days	Fri 23-10-15	Sun	Gauri	100%



PROJECT SCHEDULE-FALL

4. Planning & navigation module (Fall)	**36.19 days**	**Sun 11-10-15**	**Fri 20-11-15**	**Gauri,Rohit**	**36%**
Localization sub-module development	**30.63 days**	**Sat 17-10-15**	**Fri 20-11-15**	**Gauri,Rohit**	**39%**
Procurement of repositories, codes from Team ROBORN	3.13 days	Sat 17-10-15	Tue 20-10-15	Gauri	100%
ROS assignment tutorial	3 days	Wed 21-10-15	Fri 23-10-15	Gauri,Rohit	100%
Development of Inbuilt localization	**9.13 days**	**Fri 23-10-15**	**Mon 02-11-1**	**Gauri,Rohit**	**59%**
Turtlebot wheel calibration using ROS	3.63 days	Fri 23-10-15	Sun 25-10-15	Gauri	100%
Turtlebot IMU calibration using ROS	3 days	Mon 26-10-15	Wed 28-10-1	Rohit	100%
Development of local EKF using ROS	1 day	Thu 29-10-15	Thu 29-10-15	Gauri,Rohit	0%
Final calibration check of Turtlebot using ROS	3.63 days	Fri 30-10-15	Sun 01-11-15	Gauri,Rohit	0%
Absolute AprilTag Localization	**16.25 days**	**Tue 03-11-15**	**Fri 20-11-15**		**10%**
Procurement of AprilTags	2 days	Tue 03-11-15	Wed 04-11-1	Gauri	100%
Single AprilTag calibration with Kinect using ROS	4.13 days	Fri 06-11-15	Tue 10-11-15	Gauri,Rohit	0%
Meeting for further schedule development	1 day	Tue 10-11-15	Tue 10-11-15	Gauri,Rohit	0%
Developing World Frame using ROS	3 days	Wed 11-11-15	Fri 13-11-15	Gauri,Rohit	0%
Identify AprilTag positions in ROS environment	3 days	Wed 11-11-15	Fri 13-11-15	Gauri,Rohit	0%
Mount AprilTags in actual environment	2.06 days	Sat 14-11-15	Sat 14-11-15	Gauri,Rohit	0%
Mapping tag Ids with Tag locations in world frame using ROS	1.56 days	Sun 15-11-15	Mon 16-11-15	Gauri,Rohit	0%
Development of Global EKF in ROS	1 day	Tue 17-11-15	Tue 17-11-15	Gauri,Rohit	0%
Obtain state estimate of Kinect (Turtlebot)	3 days	Wed 18-11-15	Fri 20-11-15	Gauri,Rohit	0%
World Model Builder Development		WBD	WBD	Gauri,Rohit	0%
Global Planner sub-module Development		WBD	WBD	Gauri,Rohit	0%
Navigation sub-module development		WBD	WBD	Gauri,Rohit	0%



PROJECT SCHEDULE-SPRING

Task Name	Duration	Start	Finish	Resource Names	% Complete
5. Planning & navigation module (Spring)	**54.13 days**	Wed 20-01-16	Mon 21-03-1	**Gauri,Rohit**	**0%**
Relative AprilTag Localization	15.25 days	Wed 20-01-16	Fri 05-02-16	Gauri,Rohit	0%
World Model Builder Development	14.75 days	Sat 06-02-16	Sat 20-02-16	Gauri,Rohit	0%
Global Planner sub-module Development	14.19 days	Sun 21-02-16	Sat 05-03-16	Gauri,Rohit	0%
Navigation sub-module development	14.25 days	Sun 06-03-16	Mon 21-03-1	Gauri,Rohit	0%
6. Collaboration Module (SWARM)	**108.88 day**	**Mon 19-10-15**	**Fri 19-02-16**	**Jimit**	**0%**
Facial expression recognition with Intraface using multiple camera	15.25 days	Wed 20-01-16	Fri 05-02-16	Jimit	0%
Design, simulate and implement algorithm to follow head pose collaboratively	15.25 days	Wed 20-01-16	Fri 05-02-16	Jimit	0%
Implementating cost function for overall expression reading	15.25 days	Wed 20-01-16	Fri 05-02-16	Jimit	0%
Design, implementation and testing of best angle algorithm	15 days	Wed 20-01-16	Fri 05-02-16	Jimit	0%
SWARM module testing and validation	15 days	Fri 05-02-16	Mon 22-02-1	Jimit	0%
Best pose estimation for Smiling face in (-30,0,30) range (Find best angle)	15 days	Tue 23-02-16	Thu 10-03-16	Jimit	0%
7. Integration & testing	**139.13 day**	**Tue 01-12-15**	**Fri 06-05-16**	**ALL**	**18%**
Integration and testing of single robot	7 days	Tue 01-12-15	Tue	ALL	100%

PROJECT BUDGET

Item	Qty	Per unit cost	Total cost	Availability	Final cost
Hi-Tech HS 331 servos	12	8	96	MRSD Lab	0
10mmX2.36mm fasteners	30	6 $ (paxck of 200)	6	No	30
0.4inch X 0.094 inch fasteners	15	6 $ (paxck of 200)	6	No	15
0.8 inch X 0.15inch fastners	60	6 $ (paxck of 200)	6	No	60
4 Feet long Slotted Aluminium extrusions	12	55$/72in	440	No	440
2 Ft X 3 Ft 1.2mm thick Aluminium sheets	6	55	330	No	330
1.5 mm X 15 mm fasteners	30	6 $ (paxck of 200)	6	No	30
Logitech HD Webcam C615	1	20	20	No	20
April Tags	30	-		MRSD Lab	0
3D printed mounts for April Tags	12	-		MRSD Lab	0
Turtlebots	4	2115	8460	Dr Katya Lab	0
TOTAL					925

FALL HIGH LEVEL TEST PLAN

FALL Test Plans	Test	Progress Review
Human detection by a single Turtlebot	Turtle bot will detect a human by detecting the Apriltags attached to his feet.	PR3
Navigation and Localization of a single Turtle bot in a known environment	Turtle bot will move from one place to another while localizing itself	PR3
Integrate Intraface with Turtlebot Netbook	Turtle bot will be able to detect expression	PR3
Track and follow the Head pose of the person using Intraface software for tracking and pan tilt camera to follow the face.	Person moves head and camera moves accordingly	PR4
Multi camera expression detection		PR4
Implement flocking algorithm for three turtlebots	Turtle bots will move from one place to another but as a flock	PR4

FALL VALIDATION TEST SETUP

- **Location** - Any rectangular room with good and uniform lighting. The surface of the room shall be smooth or carpeted. There should be no obstacles. Only one human should be present in the area of testing.
- **Equipment needed** – turtle bot, pan tilt camera unit, battery (power supply).
- **Functional Requirements to be fulfilled:** • Detect human • Detect head pose • Recognizing faces • Recognizing expressions & click photos
- **Performance Requirements to be fulfilled:**

✓Detect Faces At 0.5s

✓Recognise Smiling Expression At 0.4s

✓Drive Autonomously Between Multiple Locations at 15-20cm/S

✓Detect Obstacles at 10 Cm Minimum Height

✓Click Photos In <1.5 seconds after expression detection

✓Take Pictures within 6 Ft Range

SPRING HIGH LEVEL TEST PLAN

Spring Test Plans	Month
Localization and navigation in the environment using global camera	January
Swarm expression detection algorithm integration with human detection and face pose tracking	February
Expression recognition of multiple faces in a single frame	March
Generating panorama by fusing images from multiple camera	April

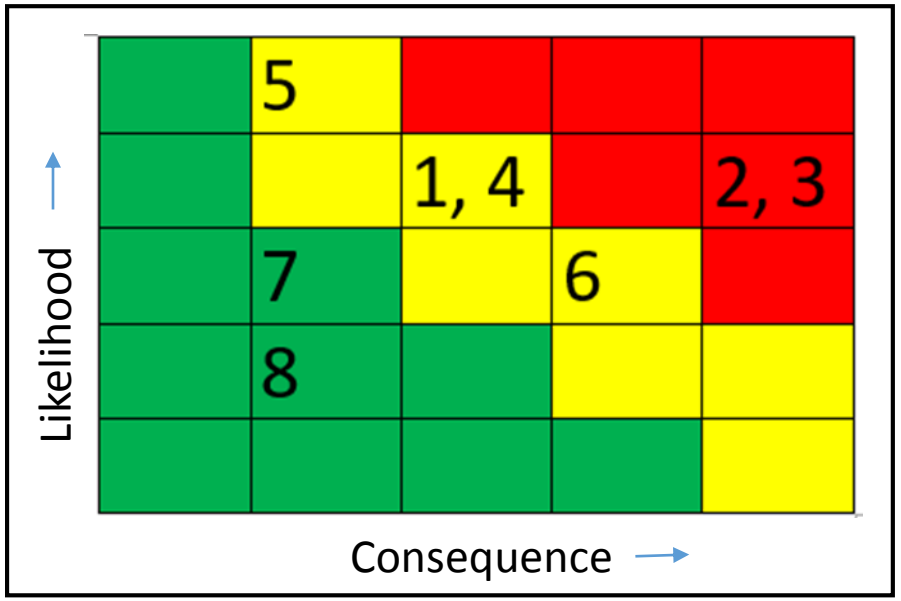
SPRING VALIDATION TEST SETUP

- **Location** - any rectangular room with good and uniform lighting. The surface of the room shall be smooth or carpeted. Obstacles present. A group of not more than 7-10 humans present in the room.
- **Equipment needed** – 4 turtle bots with mounted pan tilt camera unit, battery (power supply).
- **Requirements to be fulfilled -**

• Recognizing expressions collaboratively • Plan path • Communicate within themselves • Move autonomously from one location to another • Avoid obstacles • Click photos from best possible angles

POTENTIAL RISKS

1. Multi Camera reconstruction low robustness
2. Noisy detection in moving data
3. Intraface bugs
4. Calibration during initial setup goes wrong
5. Battery drain of Turtlebots
6. Single robot failure
7. Communication lag
8. Extra Payload



POTENTIAL RISKS AND MITIGATION STRATEGIES

Risk Name	Likelihood	Consequence	Rqt	Mitigation Strategy
1. Multi Camera reconstruction low robustness.	4	3	M.F.5	Install Intraface on each TurtleBot separately and calculate the total probability of the expression
2. Noisy detection in moving data	4	5	M.F.3, M.F.4, M.F.3	Do expression detection only when robot is not moving. We will have to adopt planning strategies. Performance requirements will be affected
3. Intraface crash	4	5	M.F.6	Get a more stable version of Intraface for the system
4. Calibration during initial setup goes wrong	4	3	M.F.9	Turtle bots need to be re-calibrated every two weeks and gyro parameters will have to be fine tuned manually
5. Battery drain of Turtlebots	5	2	M.N.9	Get new set of batteries which can be kept as extra. Sponsor has already ordered new set of batteries
6. Single robot failure	3	4	M.F.3, M.F.6, M.F.10	Make the system robust enough such that it can still perform without the robot that is not operational. Also it would be better to keep one or two extra Turtlebots by negotiating with the sponsor
7. Communication lag	3	2	M.F.10	Image and data compression algorithms need to be implemented
8. Extra Payload	2	2	M.F.8	Turtle bot may get bit slow. Make pan tilt unit as light as possible. Employ use of aluminium in final set-up.


THANK
YOU